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or about one-third of the probable error of the best Oxford photographic results.

That such accuracy can be attained in the single measurement is sufficient argument for insisting on accuracy to $\pm 0''\cdot 01$, in the determination of the division errors, where the final result may rest not only upon a single observation but on many repeated observations in which the same divisions are employed.

The whole of the observations quoted in the preceding paper have been made by myself, but some independent measures of the same errors have been made by Mr. Finlay, which show no sensible difference in his results from mine. Indeed I am now convinced that the personality frequently found in the readings of scales and circles is due to the ragged character of the edges of the divisions; and, if in future the original graduations are made with a *cutting* diamond, and the "burrs" are removed by the process above described (instead of by the method of charcoaling), and if like linear perfection of the edges of the divisions is attained, personality in reading will disappear. I do not mean that personality will disappear in the *absolute* readings (for an observer may have a tendency to place the division too much to the right or left of the middle point between the parallel wires), but that it will disappear from the *difference* of the readings on two divisions.

It may be noted, finally, that the observations of *β Centauri* above quoted, as well as other researches which will afterwards be published, afford proof of the complete elimination of systematic error depending on the direction of measurement with respect to the vertical, which is secured by the use of the reversing prism.

Royal Observatory, Cape of Good Hope:
1888, *October* 15.

On Methods of printing Stellar Charts from Photographic Negatives. By Isaac Roberts.

Since the introduction of the "Stellar Pantograver" at the meeting of this Society in November last I have taken my negative of the 1,270 polar stars, which formed one of the illustrations to the descriptive matter concerning the instrument to Col. Sir C. W. Wilson, the director of the Ordnance Survey at Southampton, and explained to him the difficulties attendant upon the transference of the images of very faint stars from negatives on to paper so as to form reliable charts; and he readily and cordially undertook to try if the methods in use for printing the maps of the Government Survey would give satisfactory results with stellar photographs. The two sheets of illustrations which I present to the Society, and which are now before us, show the fine work that Sir C. W. Wilson has been able to execute from the negative by

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his printing processes, and the results can now be compared with those obtained by aid of the pantograver.

There are eleven illustrations on each sheet, which may be described thus:—Five silver bromide prints, which were exposed to gaslight for the following intervals respectively: 20, 25, 30, 35, and 60 seconds each. Five platinotype prints, which were exposed to diffused sunlight for 3, 4, 5, 20, and 30 minutes respectively; and one photozincograph.

On the other sheet are five silver bromide prints reversed, the stars being black on a white ground. The duration of the exposures to gaslight were 1, 2, 3, 4, and 5 minutes respectively. Five platinotype prints, reversed like the bromide prints, and exposed to diffused sunlight for 25, 30, 35, 40, and 45 minutes respectively. One photozincograph, also reversed.

All the prints are remarkably sharp and clear, and obviously represent a state of perfection in instrumental, chemical, and manipulative skill that experience and ample resources can alone supply, and on the lines of the methods here illustrated it is not probable that more can be done than is here shown. Let us then compare the results with those obtained by the aid of the pantograver, and this can best be done by counting all the stars that are with certainty recognisable as such, without a magnifier, on each illustration; but, to shorten the process, I have counted the stars on three of the plates which show the largest number, with the following results: 452, 379, and 436 stars. I have also attached to the sheets two copies of the stars which were engraved with the pantograver, so that eye comparisons can readily be made. It will be evident on inspection, without the trouble of counting, that very large numbers of stars are missing from each print, and many others are reduced so that they cannot with certainty be identified as stars, and it would be impossible to measure with accuracy the stellar magnitudes on any of the prints. If any speck on the film of a negative should resemble a star it would of course print so that it could not be distinguished from a star; and on most negatives there are such specks more or less numerous.

If now we compare the foregoing results with those of the method of engraving we find the following advantages in favour of the latter:—

1. In the method of engraving, a magnifying power of about twenty-four diameters is used, and with it specks on the film are readily and with certainty distinguished from stars. The prints will therefore be free from these sources of error.

2. The engraving-instrument is made to proportionally *increase* the star diameter so that the faintest image on the film can be made visible to sight on the copper plate and on the print from it without altering the position of the centre. Accurate measurements of both positions and magnitudes of the stars can therefore be made from the engravings.

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3. No star, however faint its image may be on the film, is lost on the engraving, except through the carelessness of the operator. In the comparison we are now making with the photographic prints, which have been made, as already stated, with the highest practical skill on zinc plates, nearly two-thirds of the faint stars are lost on a single plate which covers a sky space of two degrees in diameter, and many others are so small that we are in some doubt if they really are stars, and it is hopeless to try to determine their magnitudes with accuracy.

The conclusion, then, to which we are led at present is, that any known system of charting the stars directly from the original negatives by the aid of photographic prints fails to meet the essential conditions in number of the stars charted—in the mensurability of their magnitudes, and in freedom from liability of printing specks as stars; whereas the proposed system of engraving meets fully each condition and leaves the original negative uninjured for future reference.

Photographs of the Nebulæ in the Pleiades and in Andromeda.

By Isaac Roberts.

The accompanying photograph* of the nebulæ in the *Pleiades* is an enlargement to four times the negative, taken on December 8, 1888, with exposure of the plate during four hours, and it brings to view all the nebulosity shown on the photographs which I have presented to the Society, and referred to at the meeting in January 1887 in a manner more clearly defined, though not exceeding the limits shown on those photographs. The nebulosity involves the following stars: *Asterope*, *Taygeta*, *Maia*, *Celæno*, *Electra*, *Alcyone*, stars 24,† 12, and far towards the *sp* of *Merope*. *Alcyone* is seen in the midst of a dense spiral nebula which branches in *np* direction towards and up to stars 9 and 8; and towards the north there are two faint circles of nebulous matter, one with its centre *np* star 15 and the other with its centre about midway between *Alcyone* and star 24. It is cut by a long nebulous streamer which extends both *p* and *f* star 24 and forms the chord of an arc. *Merope* is involved in dense streaky nebulosity, which extends far away in *sp* direction, where it fades gradually into the darkness of space. There is a crooked nebulous bridge connecting the *Merope* and *Alcyone* nebulæ, which passes over star 13. A nebulous straight line commences at star 7 and extends through star 1 in *p* direction till past the centre of *Electra*, where it ends. *Electra* has a horn-like projection from it, pointed towards *Alcyone*. *Maia* is involved in dense streaky nebulosity which extends to *Taygeta* and *Asterope* with a detached branch towards

* The photographs are placed in the Library. † Bessel's numbers.